

CLAIMS

1. A plug for controlling fluid flow in a well bore, the
2. plug comprising a substantially cylindrical body
3. adapted for location on a work string, the body
4. including a bore through a portion thereof and one or
5. more radial ports for passage of fluid from the bore
6. to an outer surface of the body, an actuating member
7. moveable relative to the body so as to cover the one
8. or more radial ports in a first position and uncover
9. the one or more radial ports in a second position
10. wherein movement of the actuating member is
11. controlled by an actuating mechanism, the mechanism
12. being operable under pressure in the well bore to set
13. the plug in a first natural state wherein the
14. actuating member is in the first position for a
15. pressure under a predetermined pressure range; a
16. second closed state wherein the actuating member is
17. locked in the first position regardless of the
18. pressure; and a third open state wherein the
19. actuating member is moved to the second position on
20. increasing the pressure to the predetermined pressure
21. range and holding the pressure in the range for a
22. predetermined time.
25. 2. A plug as claimed in Claim 1 wherein the actuating
26. mechanism comprises one or more pistons operated on
27. by the applied pressure.
29. 3. A plug as claimed in Claim 2 wherein the actuating
30. mechanism comprises first and second pistons; the
31. first piston including a damping element for delaying
32. movement of the first piston relative to the second

1 piston under the applied pressure; the second piston
2 acting on a retaining element; the retaining element
3 adapted to hold the second piston in an intermediate
4 position when the applied pressure is within the
5 predetermined range and allow movement of the first
6 piston to a final position; the retaining element
7 allowing the second piston to move to a secondary
8 position when the applied pressure is above the
9 predetermined range; a locking element which prevents
10 movement of the first piston when the second piston
11 is in the secondary position; and a securing element
12 for retaining the actuating member in the first
13 position until released by virtue of the first piston
14 reaching the final position, whereby the actuating
15 member moves to the second position and opens the
16 plug.

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18 4. A plug as claimed in Claim 3 wherein the damping
19 element is a fluid metering device.

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21 5. A plug as claimed in Claim 3 or Claim 4 wherein the
22 retaining element is a collet.

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24 6. A plug as claimed in Claim 5 wherein the locking
25 element is a sleeve such that the retaining element
26 and the locking element engage to control movement of
27 the pistons.

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29 7. A plug as claimed in Claim 1 wherein the actuating
30 mechanism may comprises a pressure sensor located in
31 the bore to measure the applied pressure, a processor
32 programmed to control a motor in response to the
33 pressure wherein operation of the motor causes the

1 required relative movement between the actuating
2 member and the body.

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4 8. A plug as claimed in Claim 7 wherein the mechanism
5 also comprises a securing element for retaining the
6 actuating member in the first position.

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8 9. A plug as claimed in any preceding Claim wherein the
9 actuating member is a sleeve.

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11 10. A plug as claimed in Claim 9 wherein the securing
12 element is one or more locking keys which engage with
13 the sleeve.

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15 11. A plug as claimed in any preceding Claim wherein the
16 predetermined range for the pressure is approximately
17 1200 to 1800 psi.

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19 12. An actuating mechanism for operating a tool used in a
20 well bore, the mechanism comprising first and second
21 pistons; the first piston including a damping element
22 for delaying movement of the first piston relative to
23 the second piston under an applied pressure; the
24 second piston acting on a retaining element; the
25 retaining element adapted to hold the second piston
26 in an intermediate position when the applied pressure
27 is within a predetermined range and allow movement of
28 the first piston to a final position; the retaining
29 element allowing the second piston to move to a
30 secondary position when the applied pressure is above
31 the predetermined range; a locking element which
32 prevents movement of the first piston when the second
33 piston is in the secondary position; an actuating

1 member whose movement operates the tool; and a
2 securing element for retaining the actuating member
3 in a first position until released by virtue of the
4 first piston reaching the final position, whereby the
5 actuating member moves to a second position and
6 operates the tool.

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8 13. An actuating mechanism as claimed in Claim 12 wherein
9 the first and second pistons include substantially
10 conical drive faces with apexes directed towards the
11 applied pressure.

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13 14. An actuating mechanism as claimed in Claim 12 or
14 Claim 13 wherein the damping element is a fluid
15 metering device.

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17 15. An actuating mechanism as claimed in Claim 14 wherein
18 the fluid metering device comprises a fluid filled
19 chamber through which the first piston passes and a
20 portion of the first piston includes a restrictor to
21 regulate fluid flow between upper and lower
22 compartments of the chamber.

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24 16. An actuating mechanism as claimed in Claim 15 wherein
25 a pressure balance piston is located in the chamber,
26 around the first piston so as to control the size of
27 the chamber in order to compensate for thermal
28 effects and pressure differences between inside and
29 outside the chamber.

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31 17. An actuating mechanism as claimed in any one of
32 Claims 12 to 16 wherein the retaining element is a
33 spring.

1 18. An actuating mechanism as claimed in Claim 17 wherein
2 retaining element is a collet.

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4 19. An actuating mechanism as claimed in any one of
5 Claims 12 to 18 wherein the locking element is a
6 sleeve such that the retaining element and the
7 locking element engage to control movement of the
8 pistons.

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10 20. An actuating mechanism as claimed in any one of
11 Claims 12 to 19 wherein the actuating member is a
12 sleeve and the securing element is one or more
13 locking keys which engage with the sleeve.

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15 21. A method of controlling fluid flow in a well bore,
16 the method comprising the steps:

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18 (a) locating a plug in a well bore, the plug
19 including an actuating mechanism to operate the
20 plug;
21 (b) increasing pressure from a surface of the well
22 bore to within a predetermined range; and
23 (c) keeping the pressure within the predetermined
24 range over sufficient time to cause the actuating
25 mechanism to move and open the plug.

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27 22. A method of controlling fluid flow in a well bore as
28 claimed in Claim 21 wherein the plug is as claimed in
29 any one of Claims 1 to 11.

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31 23. A method of controlling fluid flow in a well bore as
32 claimed in Claim 21 or Claim 22 wherein the method

1 includes the step of applying pressure above the
2 predetermined range.

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4 24. A method of controlling fluid flow in a well bore as
5 claimed in any one of Claims 21 to 23 wherein the
6 method includes the step of locking the plug in a
7 closed position in the event that the pressure
8 exceeds the predetermined range.

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10 25. A method of controlling fluid flow in a well bore as
11 claimed in any one of Claims 21 to 24 wherein the
12 method includes the step of performing a pressure
13 test above the plug.

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15 26. A method of controlling fluid flow in a well bore as
16 claimed in any one of Claims 21 to 25 wherein the
17 method includes the step of bringing the pressure
18 back down to below the predetermined range to then
19 perform steps (b) and (c) to open the plug.